ENCLOSURE 4

ASSESSMENT OF INTERFERENCE TO INMARSAT SATELLITE RECEIVERS USED TO SUPPORT GLOBAL MARITIME DISTRESS AND SAFETY SYSTEM AND AERONAUTICAL MOBILE SATELLITE ROUTE SERVICE OPERATIONS FROM ANCILLARY TERRESTRIAL COMPONENT MOBILE TERMINALS

BACKGROUND

The Federal Communications Commission (FCC) is currently considering a proposal from Motient Satellite Ventures (MSV) to operate an Ancillary Terrestrial Component (ATC) in the Mobile Satellite Service (MSS)[1]. The ATC is expected to augment the MSV satellite network by providing coverage in areas where satellite service is not available or significantly attenuated by natural blockage. The proposed ATC would entail a number of terrestrial Base Transceiver Systems (BTS) communicating with handheld mobile terminals (MTs) on MSS frequencies. The MSV MTs would operate in the 1626.5-1660.5 MHz band and the BTS in the 1525-1559 MHz band. In addition to the BTS, MSV will employ pico base stations operating in the 1525-1559 MHz band that may be located on ceilings ofbuildings or on building walls and will use omni-directional antennas.

Since the government and non-government share the frequencies of operations for the proposed ATC, MSV engaged the National Telecommunications and Information Administration (NTIA) in February 2002 with a presentation describing the MSV proposal.[2] At that time, MSV provided coordination and interference analyses that must be considered if and when the Commission allows such an ATC to operate in the MSS frequency bands. The coordination and interference issues presented by MSV addressed the concerns of Inmarsat Ventures PLC, who operates satellite networks in the MSS. Based on their interference analyses, MSV concluded that the proposed ATC operations would not cause interference to the Inmarsat satellite system. Inmarsat also briefed NTIA in February of 2000, but presented interference calculations that differ with the MSV conclusions.[3] Inmarsat, using similar methodology for calculating interference concluded that if the ATC were permitted, it would cause interference to the Inmarsat system.

The 1626.5-1645.5 MHz portion of the 1626.5-1660.5 MHz band is used by the United States Coast Guard (USCG) and the United States Navy (US Navy) for the Global Maritime Distress and Safety System (GMDSS) in the Earth-to-space direction. The Federal Aviation Administration (FAA) uses the 1646.5-1656.5 MHz portion of the 1626.5-1660.5 MHz band for

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[1] *In the Matter of Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Band, Notice of Proposed Rule Making*. IB Docket No. 01-185 and ET No 95-18 (rel. August 17, 2001) (the "Flexibility NPRM")

[2] Mobile Satellite Ventures LP, Presentation to NTIA, IB Docket No. 01-185 (Feb. 5, 2002) (hereinaher "MSV Presentation").

[3] Inmarsat Ventures PLC. Presentation to NTIA, IB Docket No. 01-185 (Feb. 21, 2002) (hereinafter "Inmarsat Presentation").

aeronautical mobile satellite route service (AMS(R)S) in the Earth-to-space direction. The US Navy and USCG requested that **NTIA** review Inmarsat's concerns of interference particularly with respect to aggregate interference to the Inmarsat satellite receiver from terrestrial MTs operating in the 1626.5 – 1660.5 MHz band.[4] The US Navy and USCG believe that **if** interference concerns **raised** by Inmarsat are justified GMDSS and AMS(R)S operations could be affected.

OBJECTIVE

The objective of this analysis is to perform an assessment of the potential for aggregate interference from MSV ATC MTs to an Inmarsat satellite receiver used to support GMDSS and AMS(R)S operations.

AGGREGATE INTERFERENCE TO *AN* INMARSAT SATELLITE RECEIVER

Comparison of MSV and Inmarsat Analyses

The MSV terminals will transmit in 1626.5-1660.5 MHz to communicate with either the MSV satellite using mobile earth stations or the BTS using MTs. Since Inmarsat terminals used for GMDSS and AMS(R)S operations will also transmit in this frequency band, Inmarsat is concerned that co-channel transmissions of many MSV terrestrial MTs will cause interference above the normal interference expected with MSV satellite operations without the ATC.[5]

Inmarsat and MSV used similar methodologies when computing the **level** of interference from the MSV MTs into an Inmarsat satellite receiver, however each analysis reached different conclusions. The different conclusions can be attributed to disagreement on the **values** of some technical parameters used in the interference calculations. **A** comparison of **the** values used **for** the technical parameters in the MSV and Inmarsat analyses are shown in Table 1.[6]

Table 1. Comparison of Technical Parameters used in Inmarsat and MSV Analyses

Technical Parameter	MSV	INMARSAT	Difference
Shielding Factor	10 dB	3 dB	7 dB
Satellite Receive Antenna Discrimination[7]	20 dB	**20dB**	0 dB
Vo-Coder Power Reduction Factor	7.4 dB	0 dB	7.4 dB
Power Control Factor	6 dB	2 dB	**4 dB**
Polarization Isolation	3	1.4	1.6 dB
Voice Activity Factor	1 dB	0 dB	1 dB
MT OOB Emissions	-103 0 dBW/Hz	-96 dBW/Hz	7 dBW/Hz

[4] Memorandum to Executive Secretary, IRAC from J. Hersey Jr., United States Coast Guard/Department of Transportation IRAC Representative, Subject: Terrestrial Operations in the MSS Upper and Lower "L" bands; FCC IB Docket 01-185/ET Docket 95-18 (Feb. 8,2002); Memorandum to Executive Secretary, IRAC from Bruce Swearingen, Navy IRAC Representative, Subject: Terrestrial Operaticns in the MSS Upper and Lower "L" bands; FCC IB Docket 01-185/ET Docket 95-18 (May 13,2002).

[5] **Inmarsat** Presentation at **19.**

[6] The values shown in Table 1 **for** the key parameters are from the MSV and Inmarsat presentations to NTIA.

[7] The **MSV** interference calculations **also** used 25 and 30 dB for this parameter.

The MSV and Inmarsat presentations to NTIA included calculations of co-channel and adjacent channel interference to Inmarsat satellite receivers. The parameters of disagreement account for a total of 21dB difference in the analyses presented by MSV and Inmarsat. There is also a difference in the levels for the MT out-of-band emissions used in each analysis. The MSV calculations take a more liberal approach with the various technical parameters, which serve to enhance the power reduction factors. Inmarsat, on the other hand, used more conservative values for the technical parameters.

To address the concerns raised by the USCG and the US Navy regarding GMDSS and AMS(R)S operations, NTIA performed an assessment of the potential interference from MSV MTs to an Inmarsat satellite receiver.

NTIA Analysis Overview

In this analysis the interference power density is computed using the MSV proposed co-channel and adjacent channel EIRP levels for the MTs. The computed interference power density is then compared to the interference power density threshold for the Inmarsat satellite receiver to determine the amount of available margin. Based on the available margin, the number of MTs that can be operating before the interference threshold is exceeded is determined.

The interference **power** density is computed using Equation 1.

$$I_0 = EIRP_{MT} + G_R - G(\theta) - L_P + L_{AF} - L_{POL} - L_S - L_{TPC} \quad (1)$$

where:

I_0 is the interference power density (dBW/Hz);
$EIRP_{MT}$ is the co-channel and adjacent channel EIRP density of the MTs (dBW/Hz);
G_R is the Inmarsat satellite receive antenna gain (dBi);
$G(\theta)$ is the Inmarsat satellite receive antenna discrimination (dB);
L_P is the propagation loss between the Inmarsat satellite and the MTs (dB);
L_{AF} is the MT activity factor (dB);
L_{POL} **is** the polarization loss factor (dB);
L_S is the shielding loss (dB);
L_{TPC} is the MT transmitter power control factor (dB).

The difference between the interference power density threshold and the interference power density computed using Equation 1, represents the available margin (M_{avail}). The number of MTs (N_{MT}) that would have to be in the Inmarsat satellite beam footprint before the interference power density threshold is exceeded is determined by[8]:

$$N_{MT} = 10^{M_{avail}/10}$$

[8] This assumes that the average power from multiple sources will add linearly and that for a very large number (central limit theorem) of signals a satellite receiver would see an aggregate signal that **would** produce a noise-like interference effect.

The following paragraphs discuss each of the parameters **used** in the analysis.

MT Equivalent Isotropic Radiated Power ($EIRP_{MT}$). The EIRP levels for the MTs provided by MSV are used in *this* analysis. The EIRP levels for co-channel and adjacent channel operation are –53 dBW/Hz[9] **and** –103 dBW/Hz[10] respectively.

Inmarsat Satellite Receive Antenna Gain (Gr). The mainbeam gain of **the** Inmarsat satellite receive antenna used in **this** analysis is 41 dBi.[11]

Inmarsat Satellite Receive Antenna Gain Discrimination (G(θ)). For co-channel operartion the antenna discrimination of the Inmarsat satellite receive antenna is 22 dB.[12] For adjacent channel operation the antenna discrimination of the Inmarsat satellite receive antenna is 0 dB.

Propagation Loss (Lp). The bee-space propagation model is used to compute the propagation loss between the Inmarsat satellite and the MTs. The propagation model described by the free-space **loss** equation is shown in Equation 2.

$$L_p = 20 \text{ Log } F + 20 \text{ Log } D + 32.45 \qquad (2)$$

where:

F is the frequency (MHz);
D is the distance separation between the Inmarsat satellite and the MTs (km).

The Inmarsat satellite is in geostationary orbit at a minimum distance of **35,786 km**. The free-space propagation loss for a center frequency of 1643.6 MHz is 187.8 &.

MT Activity Factor (L_{AF}). To calculate the average transmit power for a large number of MTs an activity factor should be taken into consideration. The activity factor represents the percentage of time that the MT is actually transmitting. For example, a MT that is transmitting continuously will have an activity factor of 100%. The activity factor is on average slightly less than 50% (e.g., each user in a conversation is actually speaking roughly half of the time, and there is some "idle time" for pauses)." The MT activity factor is computed **as** follows:

$$L_{AF} = 10 \text{ Log (Percentage of Time MT is Transmitting/100)} \qquad (3)$$

In this analysis it is assumed that each MT is transmitting half of the time and an activity factor of 50% is used. ***An*** activity factor of 50% equates to a *-3* dB reduction in the average power of the MT (e.g., a ratio of 0.5).

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[9] MSV Presentation **at** 21.
[10] *Id.* **at 22.**
[11] **Inmarsat Presentation at 22.**
[12] *Id* **at 17.**
[13] **Written Ex** Parte **Communication, Sprint** Corporation **and** Cingular Wireless LLC, Mobile Satellite System – *Terrestrial Services IB* Docker *No. 01-185; ET Docket No. 95-18* (May 13,2002) **Attachment A at 21** (hereinafter "2 GHz Study").

Polarization Loss (L_{POL}). Polarization loss, also referred to as polarization discrimination or polarization isolation, is the ratio at a receiving point between received power in the expected polarization and the received power in a polarization orthogonal to it from a wave transmitted with a different polarization. The polarization of an antenna remains relatively constant throughout the main lobe of the antenna pattern, but varies considerably in the minor lobes.[14] Since for the antenna directions and polarization are not known for a large number of MTs a value of 0 dB is used in this analysis for the polarization loss.

Shielding Loss (L_S). The stated purpose of the ATC is to provide coverage in areas where satellite service is not available or significantly attenuated by natural blockage such as in buildings and in urban canyons where MTs that are associated with the ATC are expected to be operating. The shielding factor is difficult to determine for a large number of MTs that can be widely distributed. The value of average shielding loss that is used in this analysis is 10 dB.[15]

Transmitter Power Control (L_{TPC}). Transmitter Power Control (TPC) will reduce the transmitter power of the MT and should be taken into consideration when calculating the average power of multiple MTs. When employed, TPC will reduce the transmit power of the MT depending upon the distance between the BTS and MT (e.g., as the MT gets closer to the BTS the transmit power will be reduced). TPC can also reduce the transmit power of the MT when there is no data to transmit (e.g., when not transmitting speech, the MT transmits a low data rate signal to maintain the link with the BTS). Both Inmarsat and MSV agree that a factor for TPC should be included in the analysis. The value of 2 dB used by Inmarsat would be applicable for a MT that is not located close to the BTS or to a MT that is transmitting data.[16] The value of 6 dB used by MSV would be more applicable to an MT operating close to a BTS or to an MT that is not transmitting data.[17] In this analysis a value of 3 dB is used as a compromise for the TPC of the MTs.

Inmarsat Satellite Receiver Interference Threshold

The interference power density threshold used in this analysis is based on an increase in the receiver noise level of the Inmarsat satellite receiver. The interference power density threshold (I_T) is computed using the following equation:

$$I_T = N_0 + I/N \tag{4}$$

where:

N_0 is the noise density of the Imarsat satellite receiver (dBW/Hz);
I/N is the interference-to-noise ratio (dB).

The noise density of the Inmarsat satellite receiver is computed using the following equation:

[14] *Antenna Engineering Handbook*, R.C Johnson, H.Jasik (Second Edition) at 1-7.
[15] NTIA Special Publication 0146, *The Potential for Accommodaiing Third Generation Mobile Systems in the 1710-1850 MHz Band* (March 2001) Appendix D at B-38.

[16] Inmarsat Presentation at 19.

[17] MSV Presentation at 25

$$N_0 = 10 \text{ Log } [(1.38 \times 10^{-23}) T] \quad (5)$$

where T is the Inmarsat satellite receiver noise temperature (K). In this analysis, a receiver noise temperature of 650 K is used.[18] The noise density of the Inmarsat satellite receiver is:

$$N_0 = -200.5 \text{ dBW/Hz}$$

The I/N used in this analysis is based on an allowable increase in the receiver noise level and is determined using the following equation:

$$I/N = 10 \text{ Log}(10^{\Delta N/10} - 1) \quad (6)$$

where AN represents the allowable increase in the receiver noise. In this analysis a 0.5 dB increase in the receiver noise is used. For a **0.5** dB increase in the receiver noise, the I/N is –9.1 dB. Using Equation **4,** the interference power density threshold used in this analysis is:

$$I_T = -200.5 \text{ dBW/Hz} - 9.1 = -209.6 \text{ dBW/Hz}$$

Analysis Results

The results of the analysis for co-channel and adjacent channel operation of MTs are provided in Table 2.

Table 2. Analysis Results

Parameter	Value	
	Co-Channel	Adjacent Channel
MT EIRP Density (dBW/Hz)	-53	-103
Inmarsat Receive Antenna Gain (dBi)	41	41
Inmarsat Receive Antenna Discrimination (dB)	-22	0
Propagation Loss (dB)	-187.8	-187.8
MT Activity Factor (dB)	-3	-3
Polarization Loss Factor (dB)	0	0
Shielding Loss (dB)	-10	-10
MT Transmitter Power Control (dB)	-3	-3
Interference Power Density (dBW/Hz)	-237.8	-265.8
Interference Power Density Threshold (dBW/Hz)	-209.6	-209.6
Available Margin (dB)	28.2	56.2
Number of MTs	661	416,869

In the United States the typical elevation angles to geostationary satellites are between 20 and 30 degrees. For a geostationary satellite the area visible on the Earth for elevation angles greater than 20 degrees is approximately 71.5×10^6 km^2. It is anticipated that over such a large visible area that the number of MTs that are operating can be significant. For co-channel

[18] Inmarsat Presentation *at* 19

operation of MTs at the emission level proposed by MSV, the results of the analysis show that only 660 MSs can be operating before the interference threshold is exceeded. This appears to be a small number of MTs given the large area visible to the satellite. However, at the level proposed by MSV for adjacent channel emissions, the analysis shows that approximately 417,000 MSs can be operating before the interference threshold is exceeded. This indicates that adjacent channel operation at the emission level proposed by MSV is feasible.

An analysis of spectrum sharing between MSS and terrestrial wireless services in the 2 GHz frequency range concluded that co-channel sharing is not feasible under any practical conditions.[19] The study also concluded that operating on separate frequencies, with appropriate guard bands to control adjacent channel interference was possible.[20] These conclusions are consistent with the results of this analysis.

CONCLUSIONS

The main problem with co-channel operation is that all MTs within the Inmarsat beam footprint contribute to the interference seen by the satellite receiver. The contribution of each MT depends on such factors as its transmit power (which may be subject to power control), and the excess attenuation in the propagation path born the MT to the spacecraft. The interference to the satellire receiver is cumulative, and will affect the uplinks from all MTs located in the satellite beam. Based on the results of the analysis shown in Table 2, co-channel operation of the MTs at the EIRP level proposed by MSV with GMDSS and AMS(R)S operations should be avoided.

Since the isolation between neighboring channels is not perfect, MTs that operate on adjacent channels will still have emissions that could impact the Inmarsat satellite receiver. Based on the results of the analysis shown in Table 2, adjacent channel operation of the MTs at the EIRP level proposed by MSV with GMDSS and AMS(R)S operations is feasible and can be effectively implemented through the coordination process that exists between MSS operators.

[19] 2 GHz Study at 77
[20] *Id.*

ENCLOSURE 5

ASSESSMENT OF INTERFERENCE TO SEARCH *AND* RESCUE SATELLITE LAND USER TERMINAL RECEIVERS FROM ANCILLARY TERRESTRIAL BASE STATIONS OPERATING IN THE 1525-1559 MHz MOBILE SATELLITE SERVICE BAND

BACKGROUND

The Federal Communications Commission (Commission) received proposals from New ICO Global Communications (Holding) Ltd. (ICO). Motient Services Inc., **and** Mobile Satellite Ventures Subsidiary (MSV)[1] to operate ancillary terrestrial base station transmitters (BTS) with their networks using assigned mobile satellite service (MSS) frequencies. The BTS would operate in the 1525-1559 MHz band (MSV Proposal)', or the 1990-2025 and 2165-2200 MHz bands (ICO Proposal). The BTS is to be integrated with the satellite network and will employ directional antennas that are expected to provide coverage to areas where the satellite signal is attenuated by foliage or terrain or to provide in-building coverage. In addition to the BTS, MSV will employ pico base stations operating in the 1525-1559 MHz band that may be located on ceilings of buildings or on building walls and will use omni-directional antennas.

The National Oceanic and Atmospheric Administration (NOAA) operates polar orbiting **and** geostationary satellites that carry Search and Rescue Satellite **(SARSAT)** payloads that provide distress alert and location information to appropriate public safety rescue authorities for maritime, aviation, and land users in distress. SARSAT consists of a network of satellites, ground stations, mission control centers, and rescue coordination centers. When an emergency beacon is activated, the signal is received by satellite and relayed to the nearest available ground station. The SARSAT ground station is referred to as a Local User Terminal (LUT). The LUTs receive information from satellites in the 1544-1545 MHz portion of the 1525-1559 MHz band. NOAA **has** 14 LUTs at **7** locations, providing total system redundancy and allows maximization of satellite tracking.

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[1] MSV **will** provide MSS throughout North America **using** the satellites launched by Motient Services Inc. and TMI Communications **and Company** Limited Partnership.

[2] *Ex parte* letter **from** Lawrence H. Williams and ***Suzanne*** Hutchings, New ICO Global Communications (Holdings) Ltd., to **Chairman** Michael K. Powell, Federal Communications Commission, IB Docket No. 99-81 (March E, 2001); Application filed by Motient Services **Inc.** and Mobile Satellite Ventures Subsidiary LLC for Assignment of Licenses and for Authority ***to*** Launch and Operate a Next-Generation Mobile Satellite Service System (March 1,2001).

OBJECTIVE

The objective of this analysis is to assess the potential of interference to SARSAT LUT receivers from the emissions of BTS operating in the 1525-1559 MHz band.

APPROACH

This analysis will determine the distance separation between the SARSAT LUT and a BTS that is necessary for compatible operation. Since the pico base stations will be employed indoors and in areas where building blockage is high they are not expected to be the limiting interference condition and therefore, are not considered in this analysis.

Analysis Overview

The received interference power level from the BTS at the input of the SARSAT LUT receiver is calculated using the following equation:

$$I = EIRP - G(\theta) + G_R - L_P - L_S \qquad (1)$$

where:

$EIRP_{BTS}$ is the MSV proposed adjacent channel EIRP for a BTS carrier (dBm/800 kHz);
$G(\theta)$ is BTS antenna gain reduction in the direction of the SARSAT LUT receiver (dB);
G_R is the mainbeam gain of the SARSAT LUT receive antenna (dBi);
L_P is the radiowave propagation loss (dB);
L_S is the system/insertion loss (dB).

In this assessment compatible operation is defined when the received interference power level from the BTS is below the interference susceptibility threshold of the SARSAT LUT receiver (I_T). The difference between the received interference power level computed using Equation 1 and the interference susceptibility threshold of the SARSAT LUT receiver represents the available margin. When the available margin is positive compatible operation is possible. The distance at which the available margin is zero represents the minimum distance necessary for compatible operation. The following paragraphs explain each of the factors used in this analysis.

BTS EIRP ($EIRP_{BTS}$). The co-channel per carrier EIRP density for a BTS is 19.1 dBW/200 kHz or -33.9 dBW/Hz.[3] The adjacent channel EIRP density per carrier for BTS emissions in the was

[3] Presentation by Mobile Satellite Ventures LP to the National Telecommunications and Information Administration: *MSV's Next Generation Satellite System Coordination and Interference Considerations* (Feb. 5, 2002) at 27.

specified as -101.9 dBW/Hz.[4] The SARSAT LUT receiver bandwidth used in this analysis is 800 kHz.[5] The adjacent channel BTS EIRP density per carrier that is used in this analysis is computed as shown in Table 1.

Parameter	Value
$EIRP_{BTS}$ (dBW/Hz)	-101.9
Conversion from Hz to 800 kHz (dB)	10 Log (200×10^3) = 59
Conversion from dBW to dBm	**30**
Adjacent Channel $EIRP_{BTS}$ (dBm/800 kHz)	-12.9

BTS Antenna Gain Reduction ($G(\theta)$)**.** The antenna pattern provided by **MSV was** used to determine the reduction in the BTS antenna gain in the direction *of* the SARSAT LUT receiver. The BTS antenna has a **5** degree tilt down angle.' Based on the antenna pattern provided by MSV and the **5** degree tilt down angle, a BTS antenna gain reduction of approximately 2 dB is **used** in this analysis.

SARSAT LUT Receive **Antenna Gain** (G_R)**.** To perform its mission, the SARSAT LUT receive antenna tracks satellites down to the horizon. Since the SARSAT LUT **tracks** down to the horizon at some point the BTS will be in the same horizontal plane as the mainbeam *of* the SARSAT LUT receive antenna. The SARSAT LUT mainbeam receive antenna gain used in this analysis is **27 dBi.**[7]

Radiowave **Propagation Loss** (L_P)**.** The Institute for Telecommunication Sciences Irregular Terrain Model (ITM) is used to compute the radiowave propagation **loss** used in this analysis.' The ITM model is based on electromagnetic theory and on statistical analysis **of** both terrain

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[4] *Id.* at 28.

[5] NTIA Special Publication 01-43 ai A-23

[6] **MSV Analysis at 3.**

[7] National Telecommunications and Information Administration, **NTIA** Special Publication 01-43, *Assessment of Compatibility Between Ultrawideband Devices and Selected Federal Systems* (Jan. 2001) at **A-24** (hereinafter " **NTIA** Special Publication 01-43").

[8] National Telecommunications and Information Administration, NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode* (April 1982).

features and radio measurements used to predict the median attenuation as a function of distance and the variability of the signal in time and space. The parameters used in the ITM model are shown in Table 2.

ITM Model Parameter	Value
Conductivity	0.0278 S/m
Permittivity	15
DeltaH	30 m
Percent Time	10%
Percent Location	50%
Percent Confidence	50%

System/Insertion Loss (L_s). The system/insertion loss represents the loss between the receiver antenna and receiver input. A insertion/system loss of 2 dB is used in the analysis for the SARSAT LUT receiver.

SARSAT LUT Receiver Interference Susceptibility Threshold (I_T). Annex A of the COSPAS-SARSAT document C/S T.002 specifies that a bit error rate (BER) of 1×10^{-6} is required to provide reliable performance on the Cospas-Sarsat processed data stream (PDS) channel. Based on the SARSAT link parameters, the required BER of 1×10^{-6} is achieved with only a 2.4 dB margin for tracking SARSAT satellites.[9]

The link must maintain a positive margin in order to achieve the required BER of 1×10^{-6}. Therefore, the total of all interference cannot be allowed to degrade the link by more than 2.4 dB. In this case the additional interference noise at the SARSAT LUT receiver is given by the following equation (numeric quantities).

$$N + I \leq 10^{(2.4/10)} * N \quad (4)$$

where:

I is the additional noise;

[9] Memorandum from Bart Sessions, Subject: Derivation of I/N ratio for UWB interference to L-Band downlink (Dec. 13,2001).

N is the SARSAT LUT receiver system noise.

Equation **4** can be rewritten as follows:

$$I/N \leq (10^{(2.4/10)} - 1) = 0.738$$

If **15%** of the **margin** were allocated to BTS interference, then $(I/N)_{BTS} = 0.1107$ (numeric) = -9.6 dB dB. This supports the I/N of -9 dB used in a previous analysis examining interference *to* SARSAT LUT receivers.[10] To compute the SARSAT LUT receiver interference susceptibility threshold the following equation is used:

$$I_T = I/N + N \qquad (7)$$

The SARSAT LUT receiver system noise in dBm, is computed using the following equation:

$$N = -198.6 \text{ dBm/°K/Hz} + 10 \text{ Log} T_s + 10 \text{ Log } B \qquad (8)$$

where

T_s is the SARSAT LUT system noise temperature (K);
B is the SARSAT LUT receiver bandwidth (Hz).

The SARSAT LUT system noise temperature is 176 K[11] and the receiver bandwidth is 800 kHz. Using Equation 8 the receiver system noise is:

$$N = -117 \text{ dBm}.$$

Using Equation 7, the SARSAT LUT receiver interference susceptibility threshold is:

$$I_T = -117 - 9 = -126 \text{ dBm}$$

Analysis Results

The results of the analysis are provided in Figure 1. As shown in Figure 1, based on the adjacent channel BTS EIRP proposed by MSV, the distance separation that is required for compatible operation with SARSAT LUTs is 30.4 km. **A** spread sheet containing the detailed

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[10] NTIA Special Publication 01-43 at **A-23**

[11] NTIA Special Publication 01-43 at **A-23**

calculations is provided in Appendix A.

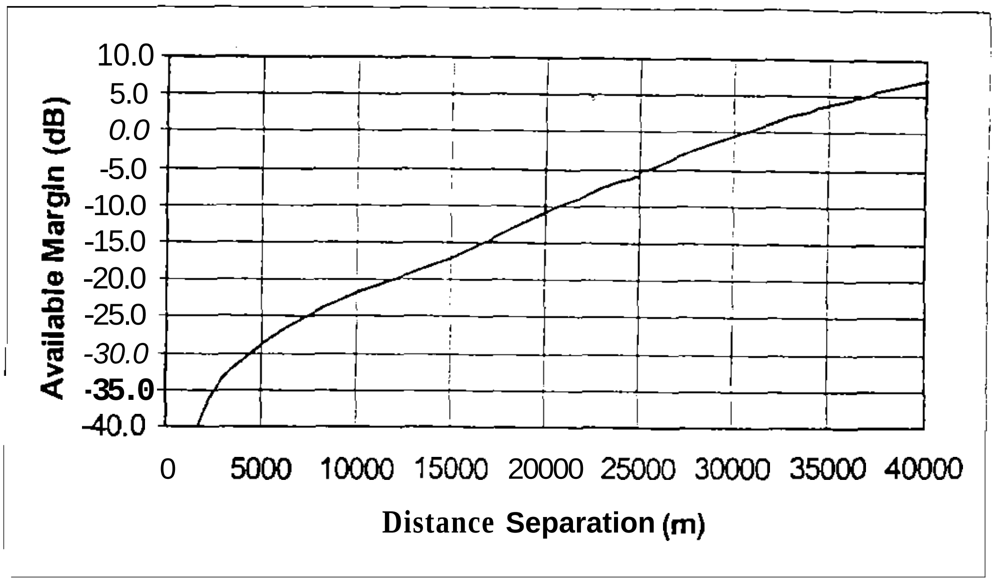

Figure 1

SARSAT LUT Location	Coordinates
Anderson AFB, Guam	13.5784°N 144.9390°E
Vandenberg AFB, CA	34.6624°N 120.5514°W
Sabana Seca USN, PR	18.4317°N 066.1922°W
USCG Station, Wahiawa, HI	21.5260°N 157.9964°W
NASA JSC, Houston, TX	29.5605°N 095.0925°W
Fairbanks, AK	64.9933°N 147.5237°W
Suitland, MD	38.8510°N 076.9310°W

CONCLUSIONS

A distance separation of 30 km is necessary between a BTS and a SARSAT LUT receiver to ensure compatible operation. Since the locations of the SARSAT LUTs are known the required distance separation can incorporated in the MSV BTS license requirements.

Possible techniques *to* reduce the required separation distance include but are not limited to:

- reduce BTS antenna gain in the direction of the SARSAT LUT;

- lower *the* BTS emission level in the 1544-1545 MHz portion of the band;

- take into account specific terrain features or other obstacles located between the BTS and SARSAT LUT location.

APPENDIX A

EIRP (dBm/800 kHz)	Gr (dBi)	Ls (dB)	DSEP (m)	HBTS (m)	HLUT (m)	SL (km)	F (MHz)	Lp(FS) (dB)	Angle, (Rad)	Theta (Deg)	Tilt Angle (Deg)	Theta-Tilt (Deg)	G(Theta-Tilt) (dB)	I (dBm)	It (dBm)	Margin (dB)
-12.9	27	2	1000	30	5	1.0	1544	93.0	0.0250	1.4	-5	-3.6	1.0	-81.8	-126.0	-44.2
-12.9	27	2	2000	30	5	2.0	1544	99.1	0.0125	0.7	-5	4.3	1.6	-88.6	-126.0	-37.4
-12.9	27	2	3000	30	5	3.0	1544	102.7	3.0083	0.5	-5	-4.5	1.8	-92.4	-126.0	-33.6
-12.9	27	2	4000	30	5	4.0	1544	105.3	0.0063	0.4	-5	-4.6	1.9	-95.1	-126.0	-30.9
-12.9	27	2	5000	30	5	5.0	1544	107.4	0.0050	0.3	-5	-4.7	1.9	-97.2	-128.0	-28.8
-12.9	27	2	6000	30	5	6.0	1544	109.1	0.0042	0.2	-5	-4.8	2.0	-99.0	-126.0	-27.0
-12.9	27	2	7000	30	5	7.0	1544	110.6	0.0036	0.2	-5	4.8	2.0	-100.5	-126.0	-25.5
-12.9	27	2	7150	30	5	7.2	1544	110.8	0.0035	0.2	-5	-4.8	2.0	-100.7	-126.0	-25.3
-12.9	27	2	8000	30	5	8.0	1544	111.9	0.0031	0.2	-5	-4.8	2.0	-101.8	-126.0	-24.2
-12.9	27	2	9000	30	5	9.0	1544	113.0	0.0028	0.2	-5	-4.8	2.0	-103.0	-126.0	-23.0
-12.9	27	2	10000	30	5	10.0	1544	114.1	0.0025	0.1	-5	-4.9	2.0	-104.1	-126.0	-21.9
-12.9	27	2	11000	30	5	11.0	1544	115.1	0.0023	0.1	-5	-4.9	2.1	-105.1	-126.0	-20.9
-12.9	27	2	12000	30	5	12.0	1544	116.1	0.0021	0.1	-5	-4.9	2.1	-106.1	-126.0	-19.9
-12.9	27	2	13000	30	5	13.0	1544	117.0	0.0019	0.1	-5	-4.9	2.1	-107.0	-126.0	-19.0
-12.9	27	2	14000	30	5	14.0	1544	118.0	0.0018	0.1	-5	-4.9	2.1	-108.0	-126.0	-18.0
-12.9	27	2	15000	30	5	15.0	1544	119.0	0.0017	0.1	-5	-4.9	2.1	-108.9	-126.0	-17.1
-12.9	27	2	16000	30	5	16.0	1544	120.1	0.0016	0.1	-5	-4.9	2.1	-110.0	-126.0	-16.0
-12.9	27	2	17000	30	5	17.0	1544	121.3	0.0015	0.1	-5	-4.9	2.1	-111.3	-126.0	-14.7
-12.9	27	2	18000	30	5	18.0	1544	122.6	0.0014	0.1	-5	-4.9	2.1	-112.6	-126.0	-13.4
-12.9	27	2	19000	30	5	19.0	1544	123.8	0.0013	0.1	-5	-4.9	2.1	-113.8	-126.0	-12.2
-12.9	27	2	20000	30	5	20.0	1544	124.9	0.0013	0.1	-5	-4.9	2.1	-115.0	-126.0	-11.0
-12.9	27	2	21000	30	5	21.0	1544	126.1	0.0012	0.1	-5	-4.9	2.1	-116.1	-126.0	-9.9
-12.9	27	2	22000	30	5	22.0	1544	127.2	0.0011	0.1	-5	-4.9	2.1	-117.2	-126.0	-8.0
-12.9	27	2	23000	30	5	23.0	1544	128.3	0.0011	0.1	-5	-4.9	2.1	-118.4	-126.0	-7.6
-12.9	27	2	24000	30	5	24.0	1544	129.4	0.0010	0.1	-5	-4.9	2.1	-119.5	-126.0	-6.5
-12.9	27	2	25000	30	5	24.5	1544	130.0	0.0010	0.1	-5	-4.9	2.1	-120.0	-126.0	-6.0
-12.9	27	2	25000	30	5	25.0	1544	130.5	0.0010	0.1	-5	-4.9	2.1	-120.5	-126.0	-5.5
-12.9	27	2	26000	30	5	26.0	1544	131.6	0.0010	0.1	-5	-4.9	2.1	-121.6	-126.0	-4.4
-12.9	27	2	27000	30	5	27.0	1544	132.6	0.0009	0.1	-5	-4.9	2.1	-122.6	-126.0	-3.4
-12.9	27	2	28000	30	5	28.0	1544	133.6	0.0009	0.1	-5	-4.9	2.1	-123.6	-126.0	-2.4
-12.9	27	2	29000	30	5	29.0	1544	134.6	0.0009	0.0	-5	-5.0	2.1	-124.6	-126.0	-1.4

-12.9	27	2	30000	**30**	5	30.0	1544	1356	0.0008	0.0	-5	-5.0	2.1	-125.6	-126.0	-0.4
-12.9	27	2	31000	**30**	**5**	31.0	1544	136.5	0.0008	0.0	-5	-5.0	2.1	-126.6	-126.0	0.6
-12.9	27	2	32000	**30**	**5**	32.0	1544	137.5	0.0008	0.0	-5	-5.0	2.1	-127.5	-126.0	1.5
-12.9	27	2	33000	**30**	**5**	33.0	1544	138.2	0.0008	0.0	-5	-5.0	2.1	-128.2	-126.0	2.2
-12.9	27	2	34000	**30**	**5**	34.0	1544	139.0	0.0007	0.0	**-5**	-5.0	2.1	-129.0	-126.0	3.0
-12.9	27	2	35000	30	5	35.0	1544	139.7	0.0007	0.0	-5	-5.0	2.1	-129.7	-126.0	3.7
-12.9	27	2	36000	30	5	36.0	1544	140.4	0.0007	0.0	-5	-5.0	2.1	-130.4	-126.0	4.4
-12.9	27	2	37000	30	5	37.0	1544	141.1	0.0007	0.0	-5	-5.0	2.1	-131.2	-126.0	5.2
-12.9	27	2	38000	30	5	38.0	1544	141.8	0.0007	0.0	-5	-5.0	2.1	-131.9	-126.0	5.9
-12.9	27	2	39000	30	5	39.0	1544	142.5	0.0006	0.0	**-5**	-5.0	2.1	-132.6	-126.0	6.6
-12.5	27	2	40000	30	5	40.0	1544	143.2	0.0006	0.0	-5	-5.0	2.1	-133.2	-126.0	7.2